REMARKS

The above amendments to claims I and 18 where made at the suggestion of the Examiner to clarify certain terms used in the claims. Therefore, by definition, their entry will serve to place the application in better condition for allowance or appeal. Hence, their entry is respectfully requested.

Applicant will now address the points raised in the Examiner's Detailed Action in the same order as they are presented.

Claim Objections

1. The suggested correction of the spelling of "ethyl benzene" in claim 7 was already made by amendment in Applicant's Response dated August 19, 2002. See page 5 of the response, claim 7, line 3. In reviewing this Response it was noticed that the "Marked Up Copy of the Amended Claims" attached to the Response did not reflect this change. Perhaps this is what caused the confusion. In any case claim 7 stands amended as suggested by the Examiner.

2. The dividing of the phrase "said oxidation chamber" in claim 18 into two paragraphs was done inadvertently during reformatting, and has been corrected in the above amended claim 18.

Claim Rejections - 35 U.S.C. § 112

4. The rejection of claims 1-7 and 13-24 under 35 U.S.C. § 112, second paragraph, on the basis the term "high temperature reaction" in claim 1 and 18 renders the claims indefinite is respectfully traversed. There is an extensive discussion and various examples given on pages 12-14 of the different types of

high temperature reactions in which the flameless distributed combustion (FDC) process heater of the invention can be employed. The general temperature range for high temperature reactions such as steam methane reforming is given on page 13, line 29 and page 14, line 1. The general temperature range for another high temperature reaction, the thermal cracking of hydrocarbons, is given on page 14, line 13. In view of the disclosure on pages 12-14 of the specification, one skilled in the art would reasonably be apprised of the type of "high temperature reactions" in which the FDC process heater of the invention can be used. Therefore, this term does not render claims indefinite, and it is respectfully requested the rejection on this basis be withdrawn.

The phraseology on lines 14-16 of claim 1, which the Examiner believes was unclear, has been replaced with the language suggested by the Examiner.

In the following paragraphs Applicant will discuss each of the terms for which the Examiner believes there is insufficient antecedent basis.

The term "the entire length" in line 7 of claim 1 clearly refers to the entire length of the oxidation chamber, the antecedent basis for which is "an oxidation chamber" on line 3 of claim 1. The term "the temperature" on line 14 of claim 1 has been changed by the above amendments to "a temperature", which term clearly refers to the temperature of said oxidant, the antecedent basis for which is "an oxidant" on lines 3-4 of claim 1. The term "the autoignition temperature" on line 16 of claim 1, clearly refers to the autoignition temperature of the "said mixture of oxidant and fuel", the antecedent basis for which is in the immediately

preceding lines. The term "the process" on line 19 of claim 1, clearly refers to the process being conducted in the process chamber, the antecedent basis for which is "a process chamber" on line 18 of claim 1 as amended above.

Applicant does not understand the Examiner's comment that " it is not clear what is the difference between various fuels recited in said claim(s)". There is only one fuel recited in the claims. That fuel is the fuel that is transported by the fuel conduit and flows through the fuel nozzles which are spaced so that no flame results when the fuel is mixed with the oxidant in the oxidation chamber. One skilled in the art would readily understand that each time the terms "fuel" or "the fuel" are used in claim 1, these terms refer a single fuel and not "various fuels". The antecedent basis for the terms "fuel" or "the fuel" is "a fuel" on line 6 of claim 1. While Applicant believes one skilled in the art would have no difficulty understanding what the term "fuel" means in claim 1 as written, in the interest of expediting allowance of the claims, Applicant has adopted the Examiner's suggestion to add the word "the" before "fuel" on lines 10, 21 and 23. Applicant did not add the word "the" before "fuel" on lines 15 and 16 of claim 1 as suggested by the Examiner, because those lines have been replaced by other language suggested by the Examiner.

Applicant does not understand the Examiner's comment that " it is not clear what is the difference between various oxidants recited in said claim(s)". There is only one oxidant recited in the claims. Applicant submits that one skilled in the art would readily understand that each time the term oxidant is used in claim 1, this term refers to a single oxidant and not "various oxidants". The

antecedent basis for the term "oxidant" is "an oxidant" on lines 3-4 of claim 1. While Applicant believes one skilled in the art would have no difficulty in understanding the meaning of "oxidant" in claim 1 as written, in the interest of expediting allowance of the claims, Applicant has adopted the changes suggested by the Examiner to replace "oxidant" on lines 21 and 23 of claim 1 with "the oxidant". Applicant did not add "the" before "oxidant " on line 16 of claim 1, since lines 14-16 have been replaced by other language suggested by the Examiner.

Applicant does not understand the rejection of claim 5 on the grounds of insufficient antecedent basis for the limitations "the thermal cracking" and "the production of olefins". 35 U.S.C. § 112 requires the claims to particularly point out and distinctly claim the subject matter of the invention. It does not require that every term used in a claim have an antecedent basis. In some cases lack of an antecedent basis can cause a term of a claim to be unclear. In many other cases it does not. In the present case the thermal cracking of hydrocarbons in the production of olefins is a well known chemical process. Claim 5 claims the process heater of claim1 wherein this well known process for the production of olefins is conducted in the <u>process chamber</u>, which is one of the three main elements of the process heater of claim 1. (See lines 18-20 of claim 1). This would be readily understood by one skilled in the art to whom the claims are directed. Therefore, claim 5 is believed to meet the clarity and definiteness requirements of 35 U.S.C § 112. There is no separate "antecedent basis"

requirement in 35 U.S.C. § 112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis should be withdrawn.

The above comments apply equally to the rejection of claim 7 on the grounds there is insufficient antecedent basis for the terms "the production of styrene" and "the dehydrogenation of ethyl benzene". The production of styrene by the dehydrogenation of ethyl benzene is a well known chemical process. Claim 7 claims the process heater of claim1 wherein this well known chemical process is conducted in the <u>process chamber</u>, which is one of the three main elements of the process heater of claim 1. (See lines 18-20 of claim 1). This would be readily understood by one skilled in the art to whom the claims are directed. There is no separate "antecedent basis" requirement in 35 U.S.C. § 112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis should be withdrawn.

The statement that Claim(s) 7 recite(s) the limitation(s) "the vacuum flash distillation" is incorrect. Apparently the Examiner intended to refer to claim14. In any case this rejection should be withdrawn for the reasons discussed above. Claim 14 claims the process heater of claim 1 wherein the process chamber is used for the vacuum distillation of a feed which is a well known refinery process. As such, the language of claim 14 is clear and the rejection on the grounds of insufficient antecedent basis should be withdrawn.

The term "the entire length" on line 8 of claim 18 clearly refers to the entire length of the oxidation chamber, the antecedent basis for which is "an oxidation chamber" on line 3 of claim 18. The term "the temperature" on line 14 of claim 18

clearly refers to the temperature of the mixture of the oxidant and fuel, which mixture results when said oxidant and said fuel are mixed in said oxidation chamber. (See lines 13-14 of claim 18). The term "the autoignition temperature" on line 15 of claim 1, clearly refers to the autoignition temperature of the "said mixture", the antecedent basis for which is "said mixture of said oxidant and said fuel" on lines 14-15 of claim 18. The term "the desired temperature" on line 19 of claim 18, clearly refers to the desired temperature distribution within the process chamber, the antecedent basis for which is "a process chamber" on line 17 of claim 18. The term "the heat flux" on line 20 of claim 18, clearly refers to the heat flux necessary to complete the process being conducted in the process chamber, the antecedent basis for which is "a process chamber" on line 17 of claim 18. The term "the process" on line 21 of claim 1, clearly refers to the process being conducted in the process chamber, the antecedent basis for which is "a process chamber" on line 17 of claim 18 as amended above.

Claim 18 has been amended to recite "said fuel" on lines 9, 14 and 15, and "said oxidant" on lines 10 and 15, as suggested by the Examiner, although Applicant believes that one skilled in the art would readily understand that the terms "fuel" and "oxidant" as used in claim 18 refer to a single fuel and a single oxidant and not "various fuels" or "various oxidants". Nevertheless, Applicant adopted the Examiners suggested changes in the interest of reducing issues and expediting allowance of the claims.

The term "the process" in claim 19, which depends from claim 18, clearly refers to the process being conducted in the process chamber, which is one of

the three main elements of the process heater of claim 18. (See lines 17-21 of claim 18). This would be readily understood by one skilled in the art to whom the claims are directed. Therefore, claim 19 is believed to meet the clarity and definiteness requirements of 35 U.S.C § 112. There is no separate "antecedent basis" requirement in 35 U.S.C. § 112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis should be withdrawn.

Claim 20 claims the flameless distributed combustion process heater of claim18 wherein the well known process of "the thermal cracking" of hydrocarbons in "the production of olefins" is conducted in the process chamber, which is one of the three main elements of the flameless distributed combustion process heater of claim 18. (See lines 17-21 of claim 18). This would be readily understood by one skilled in the art to whom the claims are directed. Therefore, claim 20 is believed to meet the clarity and definiteness requirements of 35 U.S.C. § 112. There is no separate "antecedent basis" requirement in 35 U.S.C. § 112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis should be withdrawn.

Claim 22 claims the flameless distributed combustion chamber of claim 18 wherein the well known process for the production of styrene by the dehydrogenation of olefins is conducted in the process chamber of said flameless distributed combustion process heater. This would be readily understood by one skilled in the art to whom the claims are directed. Therefore, claim 22 is believed to meet the clarity and definiteness requirements of 35 U.S.C. §112. There is no separate "antecedent basis" requirement in 35 U.S.C. §

112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis for the terms "the process", the production of styrene" and "the dehydrogenation of ethyl benzene" should be withdrawn.

Applicant does not understand the rejection of claim 23 on the grounds there is insufficient basis for the term "the process". Clearly the term "the process" refers to the steam reforming process which is conducted in the process chamber of the flameless distributed combustion process heater of claim 18, from which claim 23 depends. This would be readily understood by one skilled in the art to whom the claims are directed. Therefore, claim 23 is believed to meet the clarity and definiteness requirements of 35 U.S.C. § 112. There is no separate "antecedent basis" requirement in 35 U.S.C. § 112. Accordingly, the rejection of this claim on the grounds of insufficient antecedent basis for the term "the process" should be withdrawn.

Claim Rejections - 35 U.S.C. § 103

The rejection of claims 1-7, 13-16 and 18-23 under 35 U.S.C. § 103(a) as being unpatentable over Ruhl (EP 0 450 872) is respectfully traversed.

In applying 35 U.S.C. § 103, the following basic tenets of patent law must be adhered to:

(A) The claimed invention must be considered as a whole;

(B) The references must be considered as a whole and must suggest the desirability and thus obviousness of making the combination;

(C) The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention; and

(D) Reasonable standard of success is the standard with which obviousness

is determined. *Hodosh v Block Drug Co. Inc.* 786 F.2d 1136, 1143 n.5 USPQ 182 n.5 (Fed. Cir. 1986).

Applicant submits that the rejection of the present claims as obvious on basis of Ruhl is not consistent with the aforementioned basic tenets of patent law for the reasons discussed below, and therefore should be withdrawn.

The Invention as a Whole

The flameless distributed combustion process heater apparatus of the present invention comprises three basic elements:

(1) An oxidation chamber containing a fuel conduit with a plurality of nozzles distributed along substantially the entire length of the oxidation chamber, said nozzles being spaced to produce combustion without a flame (this provides "flameless" combustion) when fuel is mixed with an oxidant in the oxidation chamber.

(2) A preheater for heating oxidant to a temperature that when the oxidant and fuel are mixed in the oxidation chamber, the temperature of the resulting mixture will exceed the autoignition temperature of said mixture.

(3) A process chamber in a heat exchange relationship with the oxidation chamber. Various high temperature reactions such as the steam reforming of hydrocarbons, dehydrogenation of ethyl benzene to produce styrene, and the like, can be conducted in the process chamber.

The spacing of the fuel nozzles and the distribution of the fuel nozzles along substantially the entire length of the oxidation chamber the results in flameless distributed combustion in the oxidation chamber, which provides a controllable heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein. The heat flux may be controlled to provide a uniform temperature profile, but can also provide increasing or decreasing temperature profiles. A basic advantage of the present invention is that the temperature profile, or flux of heat, may be controlled to whatever temperature profile is desired for a particular reaction. (Specification, page 6, lines 9-13) The benefits of the flameless distributed combustion process heater of the present invention include higher temperatures within metallurgical constraints, improved conversions, improved selectivities and/or product yields, reduced by-product production, reduced risk of tube failures due to "hot spots", lower energy consumption and low NO_x emissions. (Page 4 of specification, line 26 to page 5, line 9.)

The Ruhl Reference as a Whole

Ruhl disclose various apparatuses for effecting endothermic reactions such as reforming light-hydrocarbons. Pg. 4 lines 11-13. The reaction apparatuses of Ruhl include a reaction vessel for effecting the endothermic reaction, and a heat generating means comprising at least one ceramic combustion tube concentrically surrounding a fuel feed tube which extends at least partially along the length and inside of the combustion tube. The heat generating means has inlets for supplying fuel gas and air. The fuel gas an air

are combusted in the heat generating means and the heat which is generated is transferred into the reaction vessel. Pg. 4, lines 2-6. Of the apparatuses depicted in Figs. 1-5 of Ruhl, all but the apparatus of Fig. 4 show combustion show with flames. The apparatus depicted in Fig. 4 shows a feed gas tube with perforations or holes 64 at spaced intervals along its length in burner zone 68. Burner zone 68 represents <u>only a minor portion (appears to be roughly 20%)</u> of the overall length of combustion tube 30.The feed gas tube has one end plugged or otherwise closed. It is stated in Ruhl "that plug 66 need not resist very hot temperatures and thus could be made of graphite or heat resistant organic cement." (Pg. 5, lines 55-56). Thus, it is clear that the Ruhl contemplates lower temperatures in the upper part of the combustion tube (which contains the plugged end of the fuel tube), than at the lower part of the combustion tube in which the "burner zone" is located. This will also result in the provision of a <u>non-uniform heat flux</u> to the process being conducted in the reaction vessel, with more heat being provided to the lower portion of packed bed 20 than the upper portion.

<u>The Rejection Based on Ruhl</u>

The Examiner recognizes that Ruhl does not disclose the critical limitation now in each of the present claims that the fuel conduit contain a plurality of fuel nozzles distributed <u>along substantially the entire length of the oxidation chamber</u>, which is in a heat exchange relationship with the process chamber in which a high temperature reaction is being conducted. Distribution of the fuel nozzles <u>along substantially the entire length of the oxidation chamber</u> is necessary to

providing <u>a controlled heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein.</u>

Although recognizing this deficiency in Ruhl, the Examiner takes the position that "While Ruhl does not explicitly disclose said nozzles being distributed along substantially the entire length of the oxidation chamber, the reference discloses that said nozzles are distributed in the burner zone, for the purpose of controlling the temperature of reaction occurring in the process chamber (Fig. 4 and P5/L51-57), and that other methods of staged introduction of fuel in to the oxidation chamber can also be employed."

The Examiner goes on state "In view of this teaching, and in view of general knowledge available to one of ordinary skill in the art, that heat transfer to a process can be optimized by placing a heater in a location where heat is desired, it would have been obvious to one of ordinary skill in the art at the time the invention was made to place said nozzles in any location where heat transfer to process in the process chamber is required".

Applicant contends that this statement this contradictory to two of the basic patent tenets set forth by the Federal Circuit in *Hodosh v Block Drug Co. Inc., supra.* Namely that: "The references must be considered as a whole and must suggest the desirability and thus obviousness of making the combination", and that: "The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention."

The Examiner is relying on only one reference (Ruhl) for the instant rejection. Therefore, the question is does Ruhl, taken as a whole, suggest the

desirability of distributing the fuel nozzles along substantially the entire length of the oxidation chamber in order to provide a controllable heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein.

A careful analysis of Ruhl indicates that this reference, taken as a whole, does not teach the desirability of distributing the fuel nozzles along substantially the entire length of the oxidation chamber, but in fact teaches away from such a modification. As discussed above, the feed gas tube of Ruhl only has perforations in burner zone 68, which represents approximately 20% of the combustion tube. Moreover, the gas feed tube in the apparatus in Fig. 4 has one end plugged with a plug 66 "which need not resist very hot temperatures and thus could be made of graphite or heat resistant organic cement." (Pg. 5, lines 55-56). From these statements it is clear that Ruhl designed the apparatus in Fig.4 to produce higher temperatures in the burner zone of the combustion tube and lower temperatures in the upper portion of the combustion tube, since the feed gas tube which is surrounded by the upper part of the combustion tube is plugged with a material that need not resist very high temperatures. In fact Ruhl states that one of the advantages of his reaction apparatus is that "it allows for the use of relatively low-temperature seals. (Pg. 3, lines 54-55).

Certainly there is nothing in these teachings which would suggest increasing the perforations from along about 20% of the feed gas tube to along substantially the entire length of the feed gas tube. To do so would significantly increase the temperature of the plugged end of the feed gas tube which is not

designed to withstand high temperatures. Thus, Ruhl, actually teaches away from desirability of modifying the apparatus in the manner suggested by the Examiner.

The general statement in Ruhl that "Other methods for the staged introduction of the fuel could also be employed" certainly does not suggest the desirability of distributing the fuel nozzles along substantially the entire length of the oxidation chamber. Staged introduction of fuel can be accomplished in any of a number of ways, including by the addition of fuel in increments or by the intermittent introduction of fuel. There is nothing in this statement which suggests modifying the apparatus of Ruhl to increase the perforations from along about 20% of the feed gas tube in the burner zone, to along substantially the entire length of the feed gas tube. As discussed above, to do so would significantly increase the temperature of the plugged end of the feed gas tube which is not designed to withstand high temperatures. Thus, Ruhl simply does not teach or suggest distributing the fuel nozzles along substantially the entire length of the oxidation chamber, which is a critical feature of Applicant's invention and is a limitation in each of the claims under consideration.

Nevertheless, the Examiner contends that it "in view of the general knowledge available to one of ordinary skill in the art, that heat transfer to a process can be optimized by placing the heater in a location where heat is desired, it would have been obvious to one of ordinary skill in the art at the time the invention was made to place nozzles in any location where heat transfer to a process in the process chamber is required, said locations including nozzles

along substantially the entire length of the oxidation chamber, for the purpose of optimizing heat transfer to the process chamber."

Applicant submits that the foregoing statement is inconsistent with the basic patent tenet set forth by the Federal Circuit in *Hodosh v Block Drug Co. Inc.*, supra, that: "The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention". The Examiner cites no reference to support the proposition that one of ordinary skill in the art would have the general knowledge available that "heat transfer to a process can be optimized by placing the heater in a location where heat is desired". But even assuming this is the case, in the reaction apparatus shown in Fig. 4 of Ruhl (the only apparatus shown in the Figures that even has fuel nozzles) the fuel nozzles are located in the "burner zone" which represents approximately 20% of the overall length of the combustion tube. Certainly, Ruhl, as an inventor, must be considered to have at least ordinary skill in the art. Ruhl would also be interested in optimizing heat transfer to the process being conducted in reaction apparatus shown in Fig. 4. Since Ruhl teaches this can best be accomplished by locating the fuel nozzles in the "burner zone", it is clear that Ruhl is not the source of the Examiner's knowledge that it may be beneficial to place the nozzles along substantially the entire length of the oxidation chamber. Ruhl does not teach or suggest this. The source of this knowledge is Applicant's own specification, the use of which in this manner is impermissible hindsight reconstruction. *Hodosh v Block Drug Co. Inc., supra.*

The Examiner further contends "it would have been obvious to one skilled in the art at the time the invention was made to add additional nozzles to the fuel conduit, since it has been held that mere duplication of the essential working parts of a device involves only routine skill in the art." The present invention clearly involves more than adding a few additional nozzles to feed gas tube in the reaction apparatus of Ruhl. By utilizing a fuel conduit containing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber, Applicant's apparatus operates in an different manner than the apparatus of Ruhl, (i.e., Applicant is able to achieve "distributed" combustion with permits far greater control of the heat flux to the process chamber than combustion in a "burner zone" as taught by Ruhl. Applicant's process heater is capable of providing whatever temperature distribution is desired in the process chamber, including increasing, decreasing or uniform temperature profiles.

Regarding claims 2-6, 13, 16, 19-21 and 23, Applicant does not rely on the additional limitations contained in these claims for patentability over Ruhl. Applicant submits that these claims are patentable over Ruhl for the reasons discussed above, i.e., (1) Ruhl does not teach or suggest the desirability of distributing the fuel nozzles in the fuel conduit along substantially the entire length of the oxidation chamber, and in fact teaches away from this concept, and (2) One of ordinary skill in the art following the teachings of Ruhl would place the nozzles in the "burner zone" in order to optimize heat transfer to the process. The significant benefits of distributed combustion achieved by locating the fuel nozzles <u>along substantially the entire length of the oxidation chamber</u> in order to

provide <u>a controlled heat flux to the process chamber</u> is taught in Applicant's patent application, not in the prior art. Therefore, the use of this teaching as a basis for the rejection is impermissible hindsight reconstruction.

The rejection of claims 17 and 24 under 35 U.S.C. § 103(a) as being unpatentable over Ruhl (EP 0 450 872) in view of Minet et al (USP 4,692,306) is respectfully traversed.

As discussed above, Ruhl does not teach or suggest the desirability of distributing the fuel nozzles in the fuel <u>conduit along substantially the entire length of the oxidation chamber</u>, and in fact teaches away from this concept. By spacing the fuel nozzles along substantially the entire length of the oxidation chamber, Applicant is able to achieve "distributed" combustion with permits far greater <u>control of the heat flux and the desired temperature distribution to the process chamber</u> than combustion in a "burner zone" as taught by Ruhl.

Since these limitations are present in each of claims 17 and 24 (through their dependency on claims 1 and 18, respectively), it is submitted that claims 17 and 24 are unobvious and therefore patentable for this reason alone.

The new patent reference cited by the Examiner, Minet et al, does not overcome this deficiency of Ruhl, and in fact is cited for a different purpose. To show that "It would be obvious to one skilled in the art at the time the invention was made to use the hot effluent from the process chamber in Ruhl to preheat the oxidant, as taught by Minet et al". However, the statement that Minet et al teaches preheating of the oxidant with effluent from the process or reactant chamber <u>is simply incorrect</u>.

The "reactants" in reaction chamber 14 which are heated by the hot product gases flowing through the regenerative heat transfer chamber 16 are steam and a reformable hydrocarbon feedstock (See Col. 6, lines 16-36). There is absolutely no disclosure in Minet et al of using the effluent from the reaction chamber to preheat the oxidant. In fact there is no indication the oxidant used in the catalytic reaction apparatus of Minet et al is even preheated.

The oxidant (burner air) used in catalytic reaction apparatus of Minet et al is introduced to the burner through air inlet nozzle 42 where it is mixed in zone 41 with burner fuel introduced through burner fuel nozzle 44. The premixed burner air and burner fuel flows upwardly into the burner stock chamber 46 and thereupon passes to the radiant burner core 40. The air and fuel mixture effuses laterally through the radiant burner skin whereupon combustion occurs thereby providing uniform or substantially uniform radiant heat to the reaction chamber (See Col. 4 lines 3-19). There simply is no teaching in Minet et al that the oxidant (burner air) is preheated using effluent from the reaction chamber, or that it is preheated at all.

Therefore, Minet et al adds nothing Ruhl which would render claims 17 and 24 unpatentable. Hence, the rejection of these claims as unpatentable over Ruhl in view of Minet et al should be withdrawn.

Th rejection of claims 1-7, 13-16 and 18-23 under 35 U.S.C. § 103(a) as being unpatentable over Ruhl (EP 0 450 872) in view of Mikus (USP 5,255,742), is respectfully traversed.

As discussed above, Ruhl does not teach or suggest the desirability of distributing the fuel nozzles in the fuel conduit along substantially the entire length of the oxidation chamber, and in fact teaches away from this concept.

First Applicant will review Mikus reference as a whole as required by *Hodosh v Block Drug Co. Inc., supra,* and will then discuss why this reference does not teach or suggest the desirability of modifying the endothermic reaction apparatus of Ruhl in the manner proposed by the Examiner.

The Mikus Reference as a Whole

The Mikus reference discloses a method for injecting heat into a subterranean formation of low permeability, such as diatomites and oil shale to enhance the recovery of oil (Col. 1, lines 9-10, col.3, line 3, col. 8, line 37 and col.9, line 29). The disclosed heat injection method uses a fuel gas combustor which does not require a flame in the borehole during the heating process (Col. 3, lines 1-5). The absence of flame eliminates the flame as a radiant heat source and results in a more even temperature distribution throughout the length of the burner (lines 3-5 of the abstract). The disclosed method for heating a subterranean formation requires a borehole from the surface to the subterranean formation and includes the steps of: (1) Combining a hydrocarbon fuel gas with a carbon formation suppressant; (2) passing the fuel gas and carbon formation suppressant mixture through a fuel gas conduit to a mixing point juxtapose to the formation to be heated; (3) passing a combustion air stream through an air

conduit to the mixing point; (4) preheating either the fuel gas and carbon suppressant mixture, the combustion air stream or both, such that the temperature of a mixture of the streams exceeds the autoignition temperature of the mixture of streams; (5) combining the preheated combustion air and fuel gas and carbon suppressant at the mixing point resulting in autoignition forming combustion products; and (6) passing the combustion products through the borehole from the mixing point to the surface. (Col. 3, lines 12-36). The heat injectors shown in Figs. 1-5 of Mikus all have in common, a fuel gas conduit 12 having a plurality of orifices 13, an air conduit 10, with the fuel gas conduit and air conduit both being situated in a casing cemented into wellbore using a high temperature cement. The combustion products either travel up the well bore and out an exhaust nozzle at the wellhead as in Figs. 1 and 4, or through a separate combustion gas conduit 19 as in Figs. 2, 3 and 5. The plurality of orifices in Mikus are sized to accomplish nearly even temperature distribution in the casing. A nearly even temperature profile in the casing results in more uniform heat distribution within the formation to be heated. (Col. 5, lines 46-51). While not specifically stated in Mikus, it would be known to one skilled in the art that fuel gas conduit, air conduit and combustion gas conduit in Mikus could be hundreds or even thousands of feet in length depending on the depth of the subterranean formation to be heated. Only a small portion of the overall length of the feed gas conduit would have fuel nozzles, i.e., the lower portion of the feed gas conduit within the formation to be heated. (Col. 5, lines 41 -43).

Mikus teaches that the heat is removed from the combustion chamber of the heat injectors at the relatively low heat flux rate of 375 watts per foot of length. (Col.9, lines 67-68 to col. 10, line 1).

Since the fuel gas combustor in Mikus is not a process heater, there is no process chamber or reaction chamber in which a process is being conducted, as is the case with the endothermic reaction apparatus of Ruhl and the flameless distributed combustion process heater of the present invention. For this reason the statement on page 10 of the Office Action that "the reference discloses said nozzles are distributed along the entire area where the process is occurring and where heat transfer is desired (Fig. 3)" is not correct. Mikus teaches injecting heat into a formation, i.e., in essence heating up the ground. There is no "process", as this term is used in the present claims, occurring in Mikus.

The Rejection Based on Ruhl in View of Mikus

Claims 1-7, 13-16 and 18-23 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ruhl in view of Mikus. On page 8 of the Office Action it is stated that "Regarding claim(s) 1 and 18, Ruhl, in Fig. 1 disclose(s) a process heater comprising:

- an oxidation chamber (30) having an inlet (40) for oxidant, an outlet (54) for combustion products and a flow path (30) between the inlet (40) and the outlet (54)".

Applicant agrees that these elements of claim 1 and 18 are present in the apparatus shown in Fig. 1 of Ruhl. However, the action then goes on to state that the apparatus in Fig.1 of has:

"- a fuel conduit (34) capable of transporting a fuel mixture to a fuel nozzle (Fig. 1) within the oxidation chamber (30), said nozzle providing communication from within the fuel conduit (34) to the oxidation chamber (30);"

This statement appears to be directed to claim 1 <u>prior to the amendments</u> made in Applicant's responses of August 19, 2002 and October 24, 2002. The above statement has little relevance to present claims 1 and 18 which include the limitations that the fuel conduit contain "a plurality of nozzles along substantially the entire length of the oxidation chamber" and that the fuel nozzles are spaced so that the fuel is added to the oxidation chamber at a rate that "no flame results" when the fuel is mixed the with oxidant in the oxidation chamber. The apparatus in Fig. 1 of Ruhl <u>does not contain a plurality of nozzles</u> and clearly shows a <u>flame in flame zone 50</u>. Therefore, the rejection of the present claims1 and 18, on the basis of the apparatus shown in Fig. 1 of Ruhl appears to be a mistake. If not, clarification is requested.

While the apparatus in Fig. 4 of Ruhl does have a plurality of nozzles, and does not show a flame, as previously discussed, the plurality of fuel nozzles in the apparatus of Fig. 4 of Ruhl are located in the "burner zone" which represents only about 20% of the combustion tube. The fuel nozzles are not distributed <u>along substantially the entire length of the oxidation camber</u> as required in the

instant claims. Also, the apparatus in Fig. 4 of Ruhl is designed to produce higher temperatures in the burner zone of the combustion tube and lower temperatures in the upper portion of the combustion tube, since the feed gas tube which is surrounded by the upper part of the combustion tube is plugged with a material that need not resist very high temperatures. Thus, Ruhl, taken as a whole, does not teach or suggest the desirability of distributing the fuel nozzles in the fuel conduit along substantially the entire length of the oxidation chamber, and in fact teaches away from this concept in that Ruhl desires a lower temperature in the upper portion of combustion tube in his apparatus.

Referring now to the Mikus reference, for the sake of the record, Applicant would like to point out that statement on page 9 of the Office Action that "Mikus, in Fig. 3, teaches a process heater" is incorrect. The term "process heater" as used in the present specification and claims refers to a heater used to provide a controlled heat flux to an endothermic process in a process chamber, which is a essential element of the claimed process heater apparatus. The heat injector in Mikus has no "process chamber". It is simply used to inject heat into a subterranean formation at a relatively low heat flux, e.g., 375 watts per foot of length. (Col. 9, lines 67-68 to col. 10, line 1). Therefore, while Mikus may teach a "heater" in the broad sense, it does not teach a "process heater" as term is used in the present specification and claims.

Applicant agrees that Mikus discloses some of the benefits of flameless combustion in his heat injection process, such as more even temperature distribution throughout the length of the burner by the elimination of the flame as

a radiant heat source, the elimination of hot spots within the burner and structures surrounding the burner, and the ability to use less expensive materials of construction. However, Applicant strongly disagrees with the conclusion that stated on page 10 of the Office Action that "It would have been obvious to one skilled in the art at the time the invention was made to replace the heater in the apparatus of Ruhl with the heater of Mikus <u>for the purpose of providing more even temperature distribution throughout the length of the burner</u> and lowering the costs of said apparatus". This conclusion is based on the erroneous assumption that the "even" or "uniform" temperature distribution throughout the length of the burner, which is taught by Mikus to be beneficial in heating subterranean formations, is also beneficial in heaters used to provide heat to endothermic reactions, such as the heater used by Ruhl. This assumption is not correct, and reflects a possible misunderstanding of the present invention as well.

The heater in Fig. 4 of Ruhl does not have a "even" or "uniform" temperature distribution along its length. As previously pointed out, the "burner zone" in the lower portion of combustion tube 30 in the apparatus in Fig. 4 of Ruhl will have a higher temperature than the upper portion of the combustion tube which surrounds the feed gas tube having a plug which needn't resist high temperatures.

Ruhl didn't design his apparatus this way by accident. Some endothermic reactions require a higher heat input at the beginning of the reaction than at the end, while others require higher heat input toward the end of the reaction.

Therefore, it is reasonable to assume that Ruhl placed the fuel nozzles in the lower portion of the combustion tube intentionally in order to optimize the endothermic reaction that he was particularly interested in, i.e., the reforming of light hydrocarbons (Page 3, lines1-3).

Since the heater in Ruhl is designed to have a <u>non-uniform</u> temperature distribution along its length, and since there's no indication in Ruhl that an "even" or "uniform" temperature distribution is desirable, it would not be obvious to one skilled in the art to replace the heater in the apparatus of Ruhl with the heater in Mikus for the purpose of providing more even temperature distribution throughout the length of the burner. The teaching or suggestion to combine these references and a reasonable expectation for success <u>must both be found in the prior art</u>, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20USPQ2d 1438 (Fed. Cir. 1991).

In the present case, the fact that the heater in Mikus produces a uniform temperature distribution, does not provide any motivation or incentive to replace the heater in Ruhl with the heater of Mikus. Moreover, even if the heater in Ruhl were replaced with the heater of Mikus, it still would not produce the benefits of Applicant's process heater in providing <u>a controllable heat flux to the process chamber</u>, as discussed in greater detail below.

The flameless distributed combustion process heater of the present invention is designed to provide a <u>controllable heat flux</u> to the process chamber (Page 4, lines12-14, of the specification). The heat flux may be controlled to provide a uniform temperature profile, but can also <u>provide increasing or</u>

decreasing temperature profiles (Page 6, lines 11-12). A basic advantage of the present invention is that the temperature profile, or flux of heat, may be controlled to whatever temperature profile is desired for a particular reaction. (Specification, page 6, lines 12-13).

The limitations that the plurality of nozzles be distributed "along substantially the entire length of the oxidation chamber" and that "a controllable heat flux is provided to the process chamber at a sufficiently high rate to complete the process being conducted therein" are included claim 1, while the limitation that "said plurality of nozzles distributed along substantially the entire length of said oxidation chamber being sized to provide the desired temperature distribution within said process chamber" is included in claim 18.

In view of these limitations, it is submitted that the present claims are clearly patentable over the teachings of Ruhl and Mikus, neither of which discloses a plurality of fuel nozzles distributed along substantially the entire length of the oxidation chamber which enables the provision of a controllable heat flux to the process chamber.

On page 10 of the Office Action it is stated that it would have been obvious to one having ordinary skill in the art "to add additional nozzles to the fuel conduit". As discussed above, the present invention clearly involves more than the addition of a few fuel nozzles to the to fuel conduit in the heat injector of Mikus. By utilizing a fuel conduit containing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber, Applicant's process heater is able to provide a controlled heat flux to the process chamber, which

facilitates completion of the reaction being conducted therein. This concept is totally lacking in Mikus, which does not have a process chamber, and is not at all concerned with providing heat at a sufficiently high rate to complete the process being conducted therein.

Regarding the comments on pages 10 and 11 of the Office Action concerning claims 2-4 and claims 5-6, 13, 16 19-21, Applicant does not rely on the additional limitations contained in these claims for patentability over Ruhl in view of Mikus. Applicant submits that these claims are patentable over Ruhl in view Mikus for all of the reasons discussed above. (1) Ruhl does not teach or suggest the desirability of distributing the fuel nozzles in the fuel conduit along substantially the entire length of the oxidation chamber, and in fact teaches away from this concept, and (2) One of ordinary skill in the art following the teachings of Ruhl would place the nozzles in the burner zone in order to optimize heat transfer to the process. The significant benefits of distributed combustion achieved by locating the fuel nozzles along substantially the entire length of the oxidation chamber in order to provide a controlled heat flux to the process chamber is taught in Applicant's patent application, not in the prior art. Therefore, the use of this teaching as a basis for the rejection is impermissible hindsight reconstruction.

Regarding the comments on page 11 of the Office Action concerning claims 1-7, 13-16 and 18-23, Applicant is not relying on the manner in which the claimed apparatus is intended to be employed to distinguish the claimed apparatus from the prior art apparatus satisfying the claimed structural

limitations. Ruhl does not satisfy the claimed structural limitations in that endothermic reaction apparatus of Ruhl does not have a plurality of fuel nozzles distributed along substantially the entire length of the oxidation chamber. Mikus does not satisfy the claimed structural limitations in that the burner apparatus in Mikus does not have a process chamber, also does not have a plurality of nozzles along substantially the entire oxidation chamber. Thus, Applicant is relying on structural limitations to distinguish the claimed process heater apparatus, and not the manner in which it is intended to be used.

The Rejection of Claims 17 and 24 under 35 U.S.C. § 103(a) as being unpatentable over Ruhl in view of Mikus and further in view of Minet et al is respectfully traversed.

As discussed above, all of the present claims, including claims 17 and 24, are believed to be patentable over Ruhl, either alone or in combination with Mikus, because neither reference teaches desirability of distributing "a plurality of fuel nozzles in a fuel conduit along substantially the entire length the oxidation chamber" or "providing a controllable heat flux or "a desired temperature distribution" to a process chamber. In fact, Ruhl teaches away from this concept in that the only fuel nozzles in Ruhl are in the "burner zone". The apparatus in Mikus doesn't even have a process chamber and is not concerned with providing heat to a process.

The new patent reference cited by the Examiner, Minet et al, does not overcome any of the deficiencies of Ruhl or Mikus, and in fact is cited for a different purpose. To show that "It would be obvious to one skilled in the art at

the time the invention was made to use the hot effluent from the process chamber in Ruhl to preheat the oxidant, as taught by Minet et al". However, the statement that Minet et al teaches preheating of the oxidant with effluent from the process or reactant chamber is simply incorrect.

The "reactants" in reaction chamber 14 which are heated by the hot product gases flowing through the regenerative heat transfer chamber 16 are steam and a reformable hydrocarbon feedstock (See Col. 6, lines 16-36). There is absolutely no disclosure in Minet et al of using the effluent from the reaction chamber to preheat the oxidant. In fact there is no indication the oxidant used in the catalytic reaction apparatus of Minet et al is even preheated.

The oxidant (burner air) used in catalytic reaction apparatus of Minet et al is introduced to the burner through air inlet nozzle 42 where it is mixed in zone 41 with burner fuel introduced through burner fuel nozzle 44. The premixed burner air and burner fuel flows upwardly into the burner stock chamber 46 and thereupon passes to the radiant burner core 40. The air and fuel mixture effuses laterally through the radiant burner skin whereupon combustion occurs thereby providing uniform or substantially uniform radiant heat to the reaction chamber (See Col. 4 lines 3-19). There is no teaching in Minet et al that the oxidant (burner air) is preheated effluent from the reaction chamber, or that it is preheated at all.

Therefore, Minet et al adds nothing Ruhl or Mikus which would render claims 17 and 24 unpatentable. Hence, the rejection of claims 17 and 24 on the basis of Ruhl in combination with Mikus and Minet et al should be withdrawn.

In response to the statement in the fourth paragraph on page 12 of the Office Action regarding claims 17 and 24, Applicant is not relying on the manner in which the claimed apparatus is intended to be employed to distinguish the claimed apparatus from the prior art apparatus satisfying the claimed structural limitations. Ruhl does not satisfy the claimed structural limitations in that endothermic reaction apparatus of Ruhl does not have a plurality of fuel nozzles distributed along substantially the entire length of the oxidation chamber. Mikus does not satisfy the claimed structural limitations in that the burner apparatus in Mikus does not have a process chamber, also does not have a plurality of nozzles along substantially the entire length of the oxidation chamber. Minet et al employs an infrared burner instead of flameless combustion to provide heat to the reaction chamber in their catalytic reaction chamber. Moreover, the infrared burner in Minet et al doesn't have a fuel conduit with a plurality of fuel nozzles. Thus, Applicant is relying on the structural limitations in claims 17 and 24 to distinguish the claimed process heater apparatus, and not the manner in which it is intended to be used.

The Examiner's position as set forth on pages 12-13 of the Office Action is based on the erroneous assumption that Ruhl requires uniform heat transfer. It does not. Therefore, it would not be obvious to replace the burner in Ruhl with the flameless heater of Mikus which provides an even temperature.

At the bottom of page 12 of the Office Action the Examiner states that: It is the Examiner's position that, since there is a multitude of variables which can be adjusted in any heater operation to change heat flux of said heater, said

variables including the flow rates of gases being burned, composition of fuel being burned, the tube design (materials of construction, length and diameter), heat transfer properties of material being heated, number of heaters, etc. it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the flameless heater of Mikus in any process which requires uniform heat transfer, such as the process of Ruhl, and if necessary to modify the operation of said heater, possibly by varying some of the aforementioned variables, to provide whatever heat is required by said process" (emphasis added).

As discussed in the previous sections, the burner in the endothermic reaction apparatus in Fig. 4 of Ruhl does not provide uniform heat transfer. All of the fuel nozzles are placed in the burner zone at the lower part of the combustor tube. The upper portion of the tube is necessarily at a lower temperature since the plug at the top of the feed gas tube is said to be made from materials which needn't resist high temperatures. Thus, contrary to the above statement in the Office Action, Ruhl does not require (or even desire) uniform heat transfer. Therefore, there is no motivation or suggestion provided in the references for placing the flameless heater of Mikus (which produces an even temperature distribution along the length of the burner) into the reaction apparatus of Ruhl requires a burner having a non-uniform temperature along the length of the burner.

It basic patent law that the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art

also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ 2d 1430 (Fed. Cir. 1990). Although a prior art device "may be capable of being modified to run the way the apparatus is claimed, there must be a suggestion or motivation in the reference to do so." 916 F.2d at 682, 16 USPQ2d at 1432.

Since Ruhl does not require or desire a uniform heat transfer along the length of the burner, there is no suggestion or motivation provided by the references to replace the heater in Ruhl with the heater of Mikus.

The fact that there may be "a multitude of variables" which could be modified or manipulated by one skilled in order in order to meet the claimed invention is not sufficient by itself to establish *prima facie* obviousness without some objective reason to combine the teachings of the references. *Ex parte Levengood*, 28 USPQ 1300 (Bd. Pat. App. & Inter. 1993).

The statements and opinions in Dr. Mikus' affidavit are supported by factual evidence and should be given appropriate weight.

Another significant reason why it would not be obvious to one skilled in art to use the heat injector of Mikus in an endothermic reaction apparatus such as disclosed in Ruhl is because of <u>the order of magnitude difference in heat flux requirements</u> between heating a subterranean formation and providing heat to an endothermic chemical reaction (See col.10,lines 6-13 of Mikus and the Affidavit by Dr. Thomas Mikus filed with Applicant's Response of August 19, 2002).

Applicant respectfully requests that the Examiner reconsider Dr. Mikus' affidavit <u>which is supported by factual evidence.</u> An important fact supporting Dr.

Mikus' statements, is that the heat flux profile required for a process for the production of ethylene by the thermal cracking of hydrocarbons is 3,500 to 7000 watts per foot compared to the heat flux required to heat subterranean formations which is 375 watts per foot. As explained in Dr. Mikus' Affidavit, the reason for the order of magnitude difference in heat flux requirements is that flowing process steams normally carry the heat away from the heat source much faster than the rocky materials found in subterranean formations which are good insulators.

These are facts which support Dr. Mikus' statement that the applicability of the flameless distributed combustion heat injectors to chemical process applications was unforeseen and not predictable, and that it was very surprising and quite unexpected to he and his co-inventors that new flameless distributed combustion heater worked as well as it did. Since Dr. Mikus' statements are supported by facts, the rationale of *In re Lindner*, 457 F.2d 506, 508, 1733USPQ 356, 358 (CCPA 1972), cited in the Office Action, does not apply. Accordingly, Dr. Mikus' Affidavit should be given appropriate weight. See *In re Lindell*, 385 F.2d 453, 155 USPQ 521 (CCPA 1967), which states that although an affiant's or declarant's opinion on the ultimate legal issue is not evidence in the case, "some weight ought to be given to a persuasively supported statement of one skilled in the art on what was not obvious to him." 385 F.2d at 456, 155USPQ at 524. Dr. Mikus as the inventor on the Mikus reference is certainly one skilled in the art. Therefore, his statement that it was unexpected and unforeseen that the flameless heater used for supplying heat at a low flux to subterranean formations

could be used to provide heat at a high flux in chemical process applications should be given appropriate weight, especially when supported by the factual evidence that an order of magnitude different heat flux was involved between the respective applications.

Regarding the statement on page 13 of the Office Action that "The applicant hasn't provided any showing that increasing the number of heaters of Mikus in the process of Ruhl would not provide heat sufficient to operate said process", Applicant submits that no such showing is necessary for the reasons stated above. There is no suggestion or motivation in the references for replacing the heater in Ruhl with the heater of Mikus, since the heater used in Ruhl provides <u>non-uniform</u> heat along the length of the burner, while the heater in Mikus provides <u>even</u> or <u>uniform</u> heat along the length of the burner.

Even if Applicant wanted to make a showing it is not clear how a showing of the type suggested by the Examiner could be made. A typical heat injector of Mikus could be hundreds, if not thousands, of feet in length, with a combustion air conduit of 3-4 inches in diameter, a fuel conduit of about 3/4 inch in diameter, with fuel nozzles in the lower end of the fuel conduit, sized to provide a nearly uniform temperature profile within the wellbore, (Col. 9, lines 3-11). On the other hand, the combustion tubes employed in the apparatus of Ruhl may have a length of 20 feet and a 0.4 inch inside diameter (Ruhl pg. 6, line 23) and will have the fuel nozzles located in the burner zone of the combustion tube.

In view of these significant differences between the combustion tubes in Ruhl and the heat injectors of Mikus, it is not clear how a showing could be

made, since obviously more is involved than merely increasing the number of heat injector tubes in order to achieve an order of magnitude increase in heat flux. The length, diameter, nozzle sizing and spacing and even the location of the nozzles on the fuel conduit would have to be substantially changed in order to adapt the heat injectors of Mikus to the reaction apparatus of Ruhl. Therefore, a showing of the type suggested in the Office Action is not only not required, but would be difficult to make without significantly modifying the heat injectors of Mikus in a way not suggested by the references themselves.

Summary

In summary, claim 1 (and the claims depending therefrom) contain the limitations that the fuel conduit contain a plurality of fuel nozzles <u>along substantially the entire length of the oxidation chamber</u> which provides <u>a controllable heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein.</u> Claim 18 (and the claims depending therefrom) contain the limitations that the fuel conduit contain a plurality of fuel nozzles <u>along substantially the entire length of the oxidation chamber</u> and that said nozzles are sized <u>to provide the desired temperature distribution within said process chamber and the heat flux necessary to complete the process being conducted therein</u>. In view of these limitations, the present claims are believed to be patentable over Ruhl, either alone or in combination with Minet and/or Mikus for the following reasons:

1. Neither Ruhl, Mikus or Minet explicitly disclose distributing the fuel nozzles along substantially the entire length of the oxidation chamber. (This is acknowledged in the Office Action.)
2. Ruhl does not teach or suggest the desirability of distributing the fuel nozzles along substantially the entire length of the oxidation chamber, but in fact teaches away from this, in that Ruhl utilizes materials that needn't resist high temperature in the upper end of the combustion tube.
3. One of ordinary skill in the art following the teachings of Ruhl would place the fuel nozzles in the "burner zone" in the lower portion of the combustion tube in order to optimize heat transfer to the process. The significant benefits achieved by locating the fuel nozzles along substantially the entire length of the oxidation chamber in order to provide a controlled heat flux to the process chamber is taught in Applicant's patent application, not in the prior art. Therefore, the use of this teaching as a basis for the rejection is impermissible hindsight reconstruction. *Hodosh v Block Drug Co. Inc.* 786 F.2d 1136, 1143 n.5 USPQ 182 n.5 (Fed. Cir. 1986).
4. The statement that Minet et al teaches preheating of the oxidant with effluent from the process or reactant chamber is simply incorrect. The "reactants" in reaction chamber 14 which are heated by the hot product gases flowing through the regenerative heat transfer chamber 16 are steam and a reformable hydrocarbon feedstock. There is absolutely no disclosure in Minet et al of using the effluent from the reaction chamber

to preheat the oxidant. In fact there is no indication the oxidant used in the catalytic reaction apparatus of Minet et al is even preheated.

5. The statement on page13 in the Office Action that it would be obvious to use the flameless heater of Mikus (which produces an even temperature distribution) "in any process which requires uniform heat transfer, such as a process of Ruhl", incorrectly assumes that the process of Ruhl requires uniform heat transfer. As discussed above, the burner in Ruhl produces non-uniform heat transfer in that the lower portion of the combustion tube (which contains the burner zone) is at a higher temperature than the upper portion of the combustion tube. Thus, it would not be obvious to replace the heater in Ruhl which produces non-uniform heat transfer along its length, with the heat injector of Mikus which produces an even or uniform heat transfer along its length.
6. Since the process in Ruhl does not require (or even desire) a uniform heat transfer, there is no motivation or suggestion provided by the references to replace the heater in Ruhl with the heater of Mikus. Absent such motivation or suggestion in the references themselves for their combination, it is not appropriate to attempt to modify the references to meet the claimed invention on the basis the general knowledge or capabilities of one skilled in the art. *Ex parte Levengood*, 28 USPQ 1300 (Bd. Pat. App. & Inter. 1993).
7. The Affidavit by Dr. Mikus does contain factual evidence, i.e., that the heat flux required for a typical endothermic chemical process such the

production of ethylene by the thermal cracking of hydrocarbons is 3,500 to 7,000 watts per foot, compared to 375 watts per foot provided by the heat injectors disclosed in Mikus. The fact that there is an order of magnitude difference between the heat flux produced by the prior art heat injectors and the heat flux required by typical endothermic chemical processes, explains why the success of the flameless distributed combustion process heater was surprising to Dr. Mikus. Since Dr. Mikus' statements <u>are supported by factual evidence</u>, his Affidavit must be given appropriate weight.

For all the foregoing reasons, and in view of the amendments and Dr. Mikus' affidavit, it is submitted that claims 1-7 and 13-24, in their present amended form are patentable. Accordingly, it is respectfully requested that these claims be allowed, and the application passed to issue.

Respectfully submitted,

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MARKED-UP COPY OF AMENDED CLAIMS

1. (Four times amended) A process heater for high temperature reactions comprising:

an oxidation chamber, the oxidation chamber having an inlet for an oxidant, an outlet for combustion products, and a flow path between the inlet and the outlet;

a fuel conduit for transporting a fuel to the oxidation chamber, the fuel conduit containing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber, each nozzle providing fluid communication from within the fuel conduit to the oxidation chamber, the fuel nozzles being spaced so that <u>the</u> fuel is added to the oxidation chamber at a rate that no flame results when the fuel is mixed with the oxidant flowing through the flow path in the oxidation chamber;

a preheater in fluid communication with the oxidation chamber inlet, the preheater capable of [increasing the temperature of the oxidant to a temperature resulting in the oxidant and fuel when mixed in the oxidation chamber being hotter than the autoignition temperature of said mixture of the oxidant and fuel] <u>preheating said oxidant to a temperature at which when said oxidant and the fuel are mixed in said oxidation chamber, the temperature of said mixture of oxidant and fuel exceeds the autoignition temperature of said mixture</u>; and

a process chamber in a heat exchange relationship with the oxidation chamber whereby a controllable heat flux is provided to the process chamber at

a sufficiently high rate to complete the process being conducted therein, and the heat transferred from the oxidation chamber to the process chamber does not cause the temperature of the mixture of the oxidant and the fuel within the oxidation chamber to decrease below the autoignition temperature of said mixture of the oxidant and the fuel in the oxidation chamber.

18. (Twice Amended) A flameless distributed combustion process heater for high temperature reactions comprising:

an oxidation chamber, said oxidation chamber having an inlet for oxidant and an outlet for combustion products, and a flow path between said inlet and outlet;

a fuel conduit for transporting fuel into said oxidation chamber, said fuel conduit containing a plurality of fuel nozzles distributed along substantially the entire length of said oxidation chamber, said fuel nozzles being spaced so that the flow of said fuel through said fuel nozzles results in no flame when the fuel passes through the nozzles and is mixed with said oxidant flowing through said flow path in said oxidation chamber;

a preheater in fluid communication with said oxidation chamber, for preheating said oxidant to above a temperature at which when said oxidant and said fuel are mixed in said oxidation chamber, the temperature of said mixture of said oxidant and said fuel exceeds the autoignition temperature of said mixture; and

a process chamber in heat exchange relationship with said

oxidation chamber, said plurality of nozzles distributed along substantially the entire length of said oxidation chamber being sized to provide the desired temperature distribution within said process chamber and the heat flux necessary to complete the process being conducted therein.